Presentation Overview

- Definitions
- Green Cluster Husking Advantages/Disadvantages
- Combine Functions and Development
- Husker Options Investigated
- Experimental Procedures
- Results
- Conclusions
Definitions

- **Green clusters**: nut clusters that have just been removed from a hazel plant
  - Can be in various stages of dry-down

- **Green cluster husking**: removal of nuts from green clusters before any post-picking drying operations
Advantages

- In all cases
  - Handling equipment/labor needs reduced
  - Less space needed for drying
  - Drying time reduced
  - Forced air drying energy needs reduced
  - Nuts at higher moisture content are less likely to crack during husking
Advantages

- Husker on harvester
  - Harvester storage bin capacity can be reduced, or keep bin size and reduce frequency of unloading
  - Husks and other harvested debris (e.g., sticks) left in field
    - Eliminates cost and equipment associated special handling of husks from a stationary husker
  - Fewer transport trips from field to drying facility
If you are handling clusters (instead of just the nuts those clusters contain) you need: 4 to 5+ times as many totes
Disadvantages

- Need a good continuous-flow, green-cluster husker
- In-shell nuts end up more discolored when husked green

Bright green husk turned purplish to black after runs through Hasatsan harvester
## Combine Harvester (a.k.a. Combine) Functions

<table>
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<tr>
<th>Combine Function</th>
<th>Definition</th>
<th>Hazelnut Combine Operation</th>
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<tr>
<td><strong>Reaping</strong></td>
<td>Collecting/gathering of crop</td>
<td>Shaking clusters off plants</td>
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<td><strong>Threshing</strong></td>
<td>Detachment (via beating) of plant elements</td>
<td>Removing nuts from clusters (green cluster husking)</td>
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<td><strong>Winnowing</strong></td>
<td>Use of air and screens to separate elements into individual streams</td>
<td>Separation of nuts from leaves, sticks, involucres &amp; other debris</td>
</tr>
</tbody>
</table>
Hazelnut Combine Harvester Development

- The Grand Plan
  - Combine reaping elements of current over-the-row (a.k.a. straddle) shaker-type harvesters, with the collection, husking, and winnowing system of common Turkish/Italian hazel harvesters

![Tonutti Hazelnut Harvester](image1)

**Tonutti Hazelnut Harvester**
from Remanzacco, UD, Italy

![Facma’s Cimina C200T](image2)

**Facma’s Cimina C200T**
from Vitorchiano, VT, Italy

![Kefeli Tarım KF-501](image3)

**Kefeli Tarım KF-501**
from Turkey

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Hazelnut Combine Harvester Development

- Five Hasatsan units from Sakarya, Turkey now in the USA
  - Mary Hovel, WI: H2100
  - Mike Lilja, MN: H2100
  - Dave Bohnhoff, WI: H2200
  - Jeff Zarnowski, NY: H2200
  - Tom Molnar (Rutgers), NJ: H2200
Large Vacuum Chamber (low air speed)

Husker

Winnowing Chamber

Material Intake Port (Vacuum hose attaches here)

Husks and unhusked nuts sucked back into vacuum chamber

Drum Sizer

In-shell nuts sucked up to top of bagging area

Recycle

Hasatsan H2100

Large/heavy debris and stones expelled out back and onto ground

Vacuum Fans

Leaves, husks and other light material blown out of fan and winnowing chamber

Winnowing fan

Material intake port

Large/heavy debris and stones expelled out back and onto ground
Hasatsan H2100 Husker

Wear Bar
Hasatsan H2100 Drum Sizer
Vacuum Fans

Large Vacuum Chamber (low air speed)

Airlock

Winnowing Chamber

Husker

Material Intake Port (Vacuum hose attaches here)

Husks and unhusked nuts sucked back into vacuum chamber

In-shells

Recycle

In-shell nuts sucked up to top of bagging area

Material intake port

Drum Sizer

Leaves, husks and other light material blown out of fan and winnowing chamber

Hasatsan H2100

Large/heavy debris and stones expelled out back and onto ground

Winnowing fan
Alternatives Investigated

- Hasatsan H2200 harvester
- Ronsheim Barrel Husker
- Bashaw X12
Sample Collection & Handling

1. Hand harvest samples from Stoughton, WI test plot. Each sample consisting of all clusters from a single plant.
2. Immediately seal samples in polyethylene bag and transport to lab.
3. Remove material for moisture content analysis:
   - Hand separate husks from nuts, weigh each fraction.
   - Oven-dry fractions at 103 C for 24 hrs, reweigh each fraction.
4. Split remaining sample into three near equal portions, weigh each portion and seal in poly bag for husking.
Sample Collection & Handling

5. Each portion husked within 1 day of harvest
6. Nuts bagged during husking are sealed in poly bags and returned to lab
7. All nuts are weighed, oven-dried, and re-weighed to determine total yield and moisture content
Comparison Sample

- To compare green versus dry cluster husking, several plants from Stoughton were machine harvested at the same time plants were first hand-picked for this study.
- Sticks were removed, material blended, placed in “flower-bulb” crates, and the crates then stacked in front of a large axial flow (a.k.a. barn) fan.
- Dried material was husked after three weeks in the lab.
- At time of husking: Husks $M_{w.b.} = 10.9\%$, Nuts $M_{w.b.} = 10.0\%$.
<table>
<thead>
<tr>
<th>Plant ID</th>
<th>Harvested Mass, lbs</th>
<th>Nut Mass as % of Total Mass</th>
<th>Moisture Content, % w.b.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>In-Shell Nuts</td>
<td>In-Shell Nut</td>
</tr>
<tr>
<td>A(1)</td>
<td>16.6</td>
<td>6.2</td>
<td>37.1</td>
</tr>
<tr>
<td>B(1)</td>
<td>20.6</td>
<td>6.2</td>
<td>30.2</td>
</tr>
<tr>
<td>C(1)</td>
<td>20.8</td>
<td>8.9</td>
<td>43.1</td>
</tr>
<tr>
<td>D(1)</td>
<td>16.2</td>
<td>5.1</td>
<td>31.7</td>
</tr>
<tr>
<td>E(2)</td>
<td>23.5</td>
<td>7.6</td>
<td>32.5</td>
</tr>
<tr>
<td>F(2)</td>
<td>13.4</td>
<td>6.6</td>
<td>49.0</td>
</tr>
<tr>
<td>G(2)</td>
<td>15.4</td>
<td>6.7</td>
<td>43.2</td>
</tr>
<tr>
<td>H(2)</td>
<td>16.1</td>
<td>5.8</td>
<td>36.0</td>
</tr>
<tr>
<td>I(2)</td>
<td>12.1</td>
<td>5.4</td>
<td>44.4</td>
</tr>
<tr>
<td>K(3)</td>
<td>17.6</td>
<td>9.2</td>
<td>52.5</td>
</tr>
<tr>
<td>L(3)</td>
<td>17.2</td>
<td>8.5</td>
<td>49.5</td>
</tr>
<tr>
<td>M(3)</td>
<td>9.9</td>
<td>4.3</td>
<td>43.6</td>
</tr>
<tr>
<td>Average</td>
<td>16.6</td>
<td>6.7</td>
<td>41.1</td>
</tr>
</tbody>
</table>
Recycle Hose

Hose drawing nuts up from drum sizer to winnowing/bagging area

Intake Hose

Open/close slide

Ran at 410 rpm

Paul Ronsheim

Hose drawing nuts up from drum sizer to winnowing/bagging area
Test Procedure: Hasatsan H2200 harvester

1. Suck up clusters with intake hose (~10 secs)
2. Collect clusters exiting drum sorter (i.e., clusters still containing nuts plus some empty involucres)
   - Clusters start falling out of drum sorter as last clusters are vacuumed (i.e., at 10 sec mark)
   - Between 30 and 40 seconds after start, all clusters thru sorting drum
3. Bag all cleaned nuts (stick-ons reran). Make sure machine’s empty
4. Repeat Steps 1 through 3 four more times with clusters from Step 2 and stick-ons from Step 3 (5 total passes)
5. Hand remove nuts still in clusters after Pass 5 (and from stick-ons that exited with nuts). Bag nuts.

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Ronsheim Barrel Husker

Flattened expanded metal – ¾ in. #9
Test Procedure Ronsheim Barrel Husker

1. Place entire sample in drum
2. Run husker for 20 seconds
3. Stir stuff around in drum to move all dislodged nuts and fine material through expanded metal screen
4. Bag material that had exited husker through screen
5. Repeat Steps 1 through 4 three more times for a total husking time of 80 seconds
6. Bag material left in husker after 80 seconds
7. Clean all bagged samples (i.e., separate nuts from debris)
Bashaw X12

Rasp bars from an old combine

19 in.
Test Procedure: Bashaw X12

1. Feed sample into husker (~ about 5 secs) while making sure output chute does not plug
   • Sample moves through husker almost instantaneously
2. Make sure all material has been removed from husker
3. Remove all detached in-shell nuts from mixture exiting husker. Bag nuts. Stick-ons stay with mixture
4. Repeat Steps 1 through 3 one more time
5. Hand remove nuts still in clusters after Pass 2 (includes removing material from stick-ons). Bag nuts
### Nut Accounting

<table>
<thead>
<tr>
<th>Plant ID</th>
<th>Percent of Input Mass Recovered as both Husked and Unhusked Nuts</th>
<th>Husk moisture content, % wet basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>77.8</td>
<td>65.4</td>
</tr>
<tr>
<td>B</td>
<td>80.7</td>
<td>75.9</td>
</tr>
<tr>
<td>C</td>
<td>79.2</td>
<td>76.3</td>
</tr>
<tr>
<td>D</td>
<td>78.9</td>
<td>76.3</td>
</tr>
<tr>
<td>E</td>
<td>79.4</td>
<td>77.2</td>
</tr>
<tr>
<td>F</td>
<td>79.5</td>
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<tr>
<td>K</td>
<td>75.9</td>
<td>79.5</td>
</tr>
<tr>
<td>L</td>
<td>76.3</td>
<td>79.5</td>
</tr>
<tr>
<td>M</td>
<td>76.1</td>
<td>79.5</td>
</tr>
</tbody>
</table>
Cracked Nuts

- Not a single green-cluster-husked nut from the 12 plants was cracked by a machine (slightly surprising)
- The Bashaw X12 will crack large nuts and some smaller dry nuts
  - Need to adjust clearance for bigger nuts??
  - Need to increases spacing of “fins” on rasp bars??
Hasatsan H2200 Performance

- Average for Dry Clusters (Husks 10.9% MC w.b.)
- Average for Green Clusters (Husks 76.9% MC w.b.)
- Range for Individual Plants

Total Nuts Removed, %

Pass 1: Unhusked (Includes Stick-ons)

Pass 2

Pass 3

Pass 4

Pass 5

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Ronsheim Barrel Husker Performance

**Average for Dry Clusters (Husks 10.9% MC w.b.)**

**Average for Green Clusters (Husks 76.9% MC w.b.)**

**Range for Individual Plants**

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Bashaw X12 Performance

- **Average for Dry Clusters (Husks 10.9% MC w.b.)**
- **Average for Green Clusters (Husks 76.9% MC w.b.)**
- **Range for Individual Plants**

<table>
<thead>
<tr>
<th></th>
<th>Pass 1</th>
<th>Pass 2</th>
<th>Unhusked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Nuts Removed, %</td>
<td>90</td>
<td>10</td>
<td>(Includes Stick-ons)</td>
</tr>
</tbody>
</table>

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Conclusion

- Bashaw X-12 was best husker (by far) considering:
  - Overall husking efficiency
  - Consistency of performance
  - Capacity
  - Throughput speed
  - A large capacity refeed system is not needed
  - Life/durability – no rubber paddles to replace
  - It’s a prototype machine that has not been optimized

- Air transport, drum sizer and winnowing elements of Hasatsan would be ideal for hazelnut combine
Effectiveness Gained with Poor Translation

Warnings you actually read! (compliments of Hasatsan)